



# ENERGY STORAGE BLACK START APPLICATION NOTE

Islanded operation, or operation in the absence of grid connection, is a primary application of energy storage systems. In the case of a microgrid, the ability to island enables energy storage to provide backup power, increasing resilience and reliability of the microgrid.

For the instance a microgrid were to be de-energized due to a grid outage, or enter a “black out” state, Dynapower has developed a simple and reliable approach to black starting or “restarting” the microgrid’s energy storage inverters.

Dynapower’s patented Black Start technology quickly restores power with a single command to a “black” microgrid. In doing so, Dynapower’s Black Start allows the inverters to provide stable voltage and frequency, while also being able to start microgrid distribution networks with magnetizing loads (transformers and motor loads) that exceed the power rating of the energy storage system’s inverters.

Additionally, with Dynapower’s Black Start technology, multiple paralleled inverters are capable of starting together while also managing the states of charge of separate batteries.

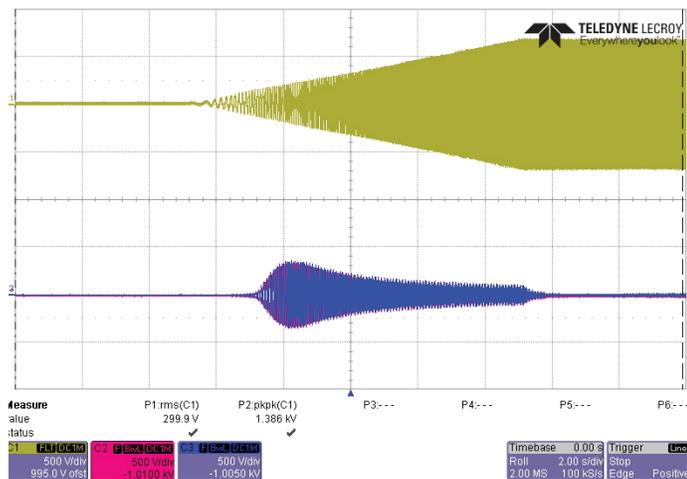


Figure 1: A single Dynapower MPS-250 inverter Black Starting a 1.5 MVA transformer.

## TURNING ON THE LIGHTS WITH ONE SWITCH

When an electrical system experiences a grid outage, or “blackout”, Dynapower inverters are able to reliably start up on their own through a start command sent by a single upper level controller. This is applicable for a single inverter systems as well as multiple inverter systems.

Without Black Start capabilities a microgrid powered by inverter based sources requires more sophisticated and costly load management to start in the absence of grid. The inverters will need to be started with all the loads isolated, then sequentially connected to manage the inrushes from the loads on the network. Alternatively, these loads could also be managed with individual VFDs, but this also adds cost to the overall system.

## CHALLENGE OF INRUSH CURRENTS

Certain loads such as transformers and induction motors can draw large amounts of current (sometimes up to 10-15 times the nameplate current rating of the load) when rated voltage is applied at their terminals. This inrush current can last up to several cycles, and until the introduction of Dynapower’s Black Start technology it had been a challenge to restart inverter-based generation sources in islanded mode.

Inrush currents are caused by transformer saturation and remanence characteristics, lack of back EMF in resting motors, and input capacitors in certain power electronic circuits. These loads are common in most microgrids.

Energy storage inverters are typically only rated to supply some overload current — typically 10-50% higher than nominal nameplate rating for short durations. Designing systems to only manage inrush current with inverter overload often leads to oversizing the inverter to an inefficient and cost prohibitive point. Dynapower’s Black Start of islanded loads eliminate the oversizing requirement. Inverters can be optimally sized for the steady state requirement of the load resulting in a cost savings for Dynapower energy storage system owners.

## DIRECT START VS. BLACK START

### Transformer Load

Transformer inrush is due to the magnetizing current of the transformer core. With Direct Start, the transformer inrush current is large enough to cause the inverter to go into current limiting mode or trip. During this time, the output voltage reduces and shows distortion due to the highly non-linear characteristics of transformer inrush.

With Dynapower’s Black Start the inverter ramps the voltage and frequency to manage the inrush currents to within the nameplate value of the inverter. These ramps are settable to ensure operation can be optimized to the particular characteristics of each site.

### Induction Motor Load

Induction motor loads pull substantial inrush currents as the rotor spins up. When the motor is direct connected, large sustained current is drawn due to high slip as the motor speeds up with rated voltage applied at its terminals. High voltage drop would be seen during startup potentially negatively affecting other system loads.

During Dynapower’s Black Start, the current drawn by the motor is contained due to the relatively gentle startup. Dynapower’s Black Start’s settable ramps in frequency and voltage allows each site to be optimized for the motor loads, transformers and capacitive banks on that particular site.

## CONCLUSION

Dynapower’s patented Black Start technology is unique in its ability to start up loads from a “black” state with a single command, and its ability to handle magnetizing loads that exceed the power rating of the inverters. In doing so, Dynapower’s Black Start technology saves money for system integrators as their systems do not need to be oversized to adequately address inrush currents.